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CLUTCH CONTROL FOR AUTOMATED MANUAL TRANSMISSION (AMT)

FIELD OF THE INVENTION

[0001] The present invention relates to clutch control, and more particularly to clutch control for an automated manual transmission (AMT).

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BACKGROUND OF THE INVENTION

[0002] Many vehicles entering the market today include automated manual transmissions (AMT's). Shift operation of an AMT is similar to that of a manual transmission. The AMT, however, includes an electronically controlled clutch and shift forks. A traditional manual transmission includes a clutch pedal and manually actuated shift forks. The electronically controlled clutch selectively couples the AMT and the engine based on signals from a controller.

[0003] AMT's simplify vehicle operation, increase driving comfort and aid in reducing fuel consumption and exhaust emission. Vehicles implementing traditional AMT's, however, experience undesired driveline oscillation. More specifically, as the electronically controlled clutch engages, the frequency of the applied engine torque contains the natural frequency of the driveline. As a result, the driveline oscillates, generating a ring.

[0004] Control techniques have been developed to counter the driveline oscillation, however, these techniques fall short. Conventional techniques are reactionary rather than proactively prohibiting driveline oscillation. For example, RPM derivative spark control (RDSC) adjusts spark timing based on the rate of change of engine speed to reduce the amplitude and duration of the driveline

oscillation. However, during clutch engagement, RDSC feature reacts to the change in engine RPM. Therefore, driveline oscillation occurs first and RDSC inhibiting second.

5 SUMMARY OF THE INVENTION

[0005] Accordingly, the present invention provides a vehicle having an engine and an automated manual transmission (AMT). The vehicle includes an electronically controlled clutch (ECC) that selectively couples the engine and the AMT to transfer drive torque
10 from the engine to the AMT. A controller communicates with the ECC and the engine and generates a load signal based on an anticipated engine load. The controller adjusts spark timing of the engine based on the load signal prior to engagement of the ECC. The controller adjusts spark timing of the engine based on a rate of change of engine
15 speed after engagement of the ECC.

[0006] In one feature, the vehicle further includes a clutch engagement sensor that generates an engagement signal based upon a degree of engagement of the ECC. The controller generates the load signal when the engagement signal is received. The clutch
20 engagement sensor generates the engagement signal immediately prior to full engagement of the ECC.

[0007] In another feature, the vehicle further includes an engine speed sensor that generates an engine speed signal and a manifold absolute pressure (MAP) sensor that generates a pressure
25 signal. The load signal is based on the engine speed signal and the pressure signal. The vehicle further includes a gear ratio sensor that generates a gear signal indicating a current operating gear of the AMT. The load signal is further based on said gear signal.

[0008] Further areas of applicability of the present invention
30 will become apparent from the detailed description provided hereinafter. It should be understood that the detailed description and

specific examples, while indicating the preferred embodiment of the invention, are intended for purposes of illustration only and are not intended to limit the scope of the invention.

5 **BRIEF DESCRIPTION OF THE DRAWINGS**

[0009] The present invention will become more fully understood from the detailed description and the accompanying drawings, wherein:

[0010] Figure 1 is a schematic illustration of a vehicle
10 including an automated manual transmission (AMT) control system according to the present invention;

[0011] Figure 2 is a more detailed view of a portion of the vehicle of Figure 1 illustrating sensors associated with an engine, clutch and the AMT; and

15 **[0012]** Figure 3 is a flowchart illustrating the AMT control according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0013] The following description of the preferred
20 embodiments is merely exemplary in nature and is in no way intended to limit the invention, its application, or uses. For purposes of clarity, the same reference numbers will be used in the drawings to identify similar elements.

[0014] Referring now to Figure 1, a vehicle 10 is
25 schematically illustrated. The vehicle 10 includes an engine 12, a clutch 14 and a transmission 16. The clutch 14 selectively couples the engine 12 and transmission 16 to transfer drive torque from the engine 12 to the transmission 16 to drive the vehicle 10. The transmission 16 is an automated manual transmission (AMT) and the clutch 14 is a
30 hydraulically controlled wet or dry clutch.

[0015] The engine 12 includes a throttle 20 and an intake manifold 22. Air is drawn into the intake manifold 22 through the throttle 20. The throttle 20 includes a throttle plate 24 that is adjustable to regulate the air flow into the intake manifold 22. The air drawn into
5 the intake manifold 22 is mixed with fuel for combustion within cylinders (not shown) of the engine 12. Combustion of the air fuel mixture is initialized by spark plugs that are controlled by an ignition system 26. Spark plug timing can be adjusted by the ignition system 26 relative to the stroke position of pistons (not shown) slidably disposed within the
10 cylinders. Spark advance or retard relative to piston stroke position varies the torque output of the engine 12.

[0016] A controller 28 controls operation of the engine 12, clutch 14 and transmission 16 based on an AMT control according to the present invention. The controller 28 communicates with the ignition
15 system 26 to control spark timing and an actuator 30 to control clutch engagement. The actuator 30 can be a mechanical actuator or a hydraulic actuator that regulates clutch engagement by varying hydraulic pressure. The controller 28 also communicates with a throttle position sensor (TPS) 32 and a throttle actuator 34. The TPS 32
20 generates a throttle position signal and the throttle actuator 34 adjusts the position of the throttle plate 24 based on a control signal generated by the controller 28.

[0017] The controller 28 also communicates with an intake manifold absolute pressure (MAP) sensor 36, an engine speed sensor
25 38, a transmission speed sensor 40, a gear sensor 42 and a clutch engagement sensor 44. The MAP sensor 36 generates a pressure signal and the engine speed sensor 38 generates a speed signal indicating the engine RPM's. The transmission speed sensor 40 generates a signal indicating the rotational speed of a transmission
30 output shaft (not shown) and the gear sensor 42 generates a signal indicating the current gear the transmission is operating in. The clutch

engagement sensor 44 detects the position of a clutch plate relative to an engine flywheel and generates a signal at the moment clutch plate and flywheel contact is imminent. The sensors are detailed in Figure 2.

[0018] The vehicle 10 further includes an accelerator pedal 46 (i.e, throttle input) and a range selector 48 (i.e., shift input). An accelerator pedal position (APP) sensor 47 generates an APP signal that is communicated to the controller 28. The controller 28 controls actuation of the throttle plate 24 based on the APP signal. The range selector 48 is a multi-state switch and includes tap-up/tap-down shift inputs 49. The range selector 48 electrically communicates with the transmission 16 to indicate an operating mode of the transmission 16. The operating modes can include, but are not limited to, reverse, neutral, drive and tap shift. In the drive mode, the controller 28 determines gear shifting based on a shift schedule. In the tap shift mode, a vehicle operator can command a gear shift (up or down). In either mode, a shift signal is generated indicating that a gear shift is desired.

[0019] The controller 28 controls the engine 12, the clutch 14 and the transmission 16 based on the AMT control. Although the controller 28 is described as a single controller that controls and monitors the powertrain of the vehicle 10, it is anticipated that the controller 28 can include separate control modules such as an engine control module (ECM) and transmission control module (TCM) that communicate via a serial bus. The controller samples engine speed, transmission input shaft speed, transmission gear, APP, MAP and clutch position and determines whether a spark knock limit is active. Spark knock limit is the maximum amount of spark adjustment allowed before engine knock occurs.

[0020] To initiate a vehicle launch, the driver depresses the accelerator pedal 46 while the vehicle is at rest. Upon indication of vehicle launch the controller 28 initiates clutch engagement. Upon the

receiving the imminent clutch engagement signal generated by the clutch engagement sensor 44, the controller 28 determines an anticipated engine load. The anticipated engine load is based on clutch capacity (i.e., clutch torque transfer capability), APP (i.e, driver torque demand), gear ratio, vehicle speed, engine speed and MAP. Immediately prior to clutch engagement, the controller 28 adjusts the spark timing of the engine based on the anticipated engine load. The controller 28 determines and schedules the spark timing based on the anticipated engine load taking into account spark knock limit.

10 **[0021]** By adjusting the spark timing immediately prior to clutch engagement, initial engine RPM droop is minimized and a faster clutch engagement is enabled. Additionally, the excitation of the natural frequency of the driveline is prevented, thereby inhibiting driveline oscillation and ringing. After the clutch 14 is engaged, the controller 28 adjusts spark timing based on RPM derivative spark control (RDSC). RDSC adjusts spark timing based on the rate of change of engine RPM. The direction and magnitude of engine RPM determines the spark timing adjustment. RDSC also inhibits driveline oscillation by preventing excitation of the natural frequency of the driveline. In this manner, spark timing is used throughout vehicle launch and afterward to reduce/increase engine torque to prevent droop or flare.

25 **[0022]** Referring now to Figure 3, the steps of the AMT control are illustrated. In step 100, control determines whether vehicle launch has been initiated. If not, control ends. Otherwise, control samples engine speed, gear, APP, MAP and clutch position in step 102. In step 104, control determines driver torque demand based on the APP signal. In step 106, control determines clutch torque capacity. The clutch engagement sensor generates the clutch position signal in step 108.

[0023] In step 110, control determines whether clutch engagement is imminent. If clutch engagement is not imminent, control continues in step 108. If clutch engagement is imminent, control continues in step 112. In step 112, control generates a spark advance
5 command based on the driver torque demand and clutch torque capacity. In step 113, control generates the clutch control command. In step 114, control samples engine speed, transmission input shaft speed and gear. In step 116 control performs clutch control based on spark advance command and clutch control command. Control
10 determines whether vehicle launch is complete in step 118. If vehicle launch is complete, control ends. If vehicle launch is not complete, control continues in step 114 to again perform clutch control based on the sampled engine speed, input shaft speed and gear.

[0024] Those skilled in the art can now appreciate from the
15 foregoing description that the broad teachings of the present invention can be implemented in a variety of forms. Therefore, while this invention has been described in connection with particular examples thereof, the true scope of the invention should not be so limited since other modifications will become apparent to the skilled practitioner
20 upon a study of the drawings, the specification and the following claims.